CLAIMS:

1. A signal broadcasting RF transmitter apparatus comprising means for generating an RF frequency-multiplexed signal comprising a plurality of frequency-spaced subcarriers in a band, characterised by means for periodically inserting data specifying the subcarriers present onto a first, predetermined, subcarrier.

2. Apparatus according to claim 1, further comprising means for varying the number of said transmitted subcarriers.

3. Apparatus according to claim 1 or 2, in which the first subcarrier is at a predetermined, frequency-constant, spectral position relative to the edge of the band irrespective of the number of subcarriers.

4. Apparatus according to claim 3, in which the first subcarrier is located edgemost, at a constant frequency, in the band.

5. Apparatus according to any of claims 1 to 4, comprising means for modulating each said subcarrier.

6. Apparatus according to claim 5 in which one said channel is modulated onto one of a pair of quadrature components of said subcarrier.

7. Apparatus according to claim 6 in which each said channel amplitude-modulates the respective quadrature component of said subcarrier.

8. Apparatus according to claim 7 in which said amplitude modulation is binary.

9. Apparatus according to any of claims 1 to 5, comprising means for modulating at least two data channels

onto a subcarrier to form each symbol thereon.

10. Apparatus according to any of claims 6 to 9, in which all channels contribute the same energy to said signal.

11. Apparatus according to any of claims 6 to 10 further comprising means for allocating channels to subcarriers such as to provide; at least one outer edge subcarrier carrying either one or two channels in dependence on whether the number of channels is odd or even, and, where the number of channels exceeds three, one or more inner subcarriers between said outer edge subcarrier and said reference subcarrier, each inner subcarrier carrying two channels.

12. Apparatus according to any preceding claim, comprising means for selectively applying either BPSK or QPSK modulation at the same symbol rate to a subcarrier.

13. Apparatus according to any preceding claim, comprising a configurable filter with a pass band set in dependence upon the number of subcarriers present.

14. A frequency-multiplexed RF signal comprising a plurality of frequency-spaced subcarriers, characterised in that it includes a first subcarrier at a predetermined frequency and in that said first subcarrier carries periodic data specifying the other subcarriers present in the frequency multiplexed signal.

15. An orthogonal frequency multiplexed RF signal carrying a first plurality of channels on a second, smaller, plurality of subcarriers, each channel modulating a quadrature component of one of said subcarriers.

16. A signal according to claim 15 in which said channels amplitude modulate said subcarriers.

17. An RF receiver apparatus comprising means for receiving an RF frequency multiplexed signal comprising a plurality of frequency-spaced subcarriers in a band, characterised by means for reading data specifying the subcarriers present from a first, predetermined, subcarrier and for configuring the receiver to receive said subcarriers.

18. Apparatus according to claim 17 comprising a configurable filter with a pass band set in dependence upon said data.

19. An OFDM receiver comprising a demodulator for demodulating a first plurality of channels from a second, smaller, plurality of subcarriers, said demodulator being arranged to demodulate each channel from one quadrature component of one subcarrier.

20. A frequency multiplexed RF signal comprising a plurality of frequency-spaced subcarriers each being modulated in a succession of data symbol periods, at least one said subcarrier being a reference subcarrier carrying orthogonal data and reference sequences of data and reference symbols respectively, in reference symbol repetition periods each of a duration of a multiple of the data symbol period duration, characterised in that, in at least first and second symbol periods within each reference symbol repetition period, the symbols carried on said reference subcarrier comprise combined symbols comprising respectively first and second different combinations of the same, repeated, data and reference symbols, said first and second combinations providing said orthogonality and permitting the separation of said data and reference symbols.

21. A signal according to claim 20 in which said reference symbols on one said reference subcarrier do not vary over time.

22. A signal according to claim 20 or claim 21, in which the amplitude of said combined symbols is the same as that of said data symbols.

23. A signal according to any of claims 20 to 22, in which the combined sample in said first symbol period is proportional to the sum of the data and reference symbols, and that in said second is proportional to the difference therebetween.

24. A signal broadcasting RF transmitter apparatus comprising a modulator arranged to modulate a plurality of frequency-spaced subcarriers with information in a succession of data symbol periods, said modulator being arranged to receive orthogonal sequences of data and reference information and to modulate at least one said subcarrier as a reference subcarrier with combined symbols comprising respectively first and second different combinations of the same, repeated, data and reference symbols, in different symbol periods, said first and second combinations providing orthogonality between said data and reference symbols and permitting the separation of said data and reference symbols at a receiver.

25. Apparatus according to claim 24 in which said reference symbols have a constant value over time on at least one said reference subcarrier.

26. Apparatus according to claim 24 or claim 25 in which the amplitude of said combined symbols is the same of that of said data symbols.

27. Apparatus according to any of claims 24 to 26, in which the combined sample in a first symbol period is proportional to the sum of the data and reference symbols, and that in a second symbol period is proportional to the difference therebetween.

28. A receiver for a frequency multiplexed RF signal comprising a plurality of frequency- spaced subcarriers each being modulated in a succession of data symbol periods, a least one said subcarrier being a reference subcarrier carrying orthogonal data and reference sequences of data and reference symbols respectively, in reference symbol repetition periods each of a duration of a multiple of the data symbol period duration, the receiver comprising means for combining the symbols received on said reference subcarriers in at least first and second symbol periods within each reference symbol repetition period to generate first and second combinations therefrom, a first combination recovering a data symbol and a second combination recovering a reference symbol, said first and second combinations providing orthogonality and permitting the separation of said data and reference symbols.

29. A receiver according to claim 28 further comprising a synchronous demodulator arranged to utilise said reference symbols to demodulate said data symbols.

30. A frequency-multiplexed signal generator generating a frequency multiplexed signal which may have, selectively, either a first format comprising at least one subcarrier or a second format comprising more subcarriers than said first format, the signal generator comprising a first signal processing circuit generating said first format, a second signal processing circuit generating said second format, and a selection circuit selecting one or other of said first or second signal processing circuits.

31. A generator according to claim 30, comprising a modulator circuit for modulating said subcarriers at a symbol rate at which said subcarriers are substantially mutually orthogonal.

32. A generator according to claim 30 or claim 31 in which said first signal processing circuit comprises at least

one pulse shaping filter.

33. A generator according to claim 32 in which said pulse shaping filter is arranged to receive an input subcarrier modulating data signal, and to shape the signal so as to concentrate the energy thereof within sample periods, between which guard intervals of reduced magnitude are inserted.

34. A generator according to claim 33 in which the frequency response of the pulse shaping filter is such as to produce a subcarrier in which the sidelobes are suppressed, relative to a (sin x/x) wave form.

35. A generator according to any of claims 30 to 34, in which said second signal processing circuit acts as a bank of (sin x/x) filters.

36. A generator according to any of claims 30 to 35, in which said second signal processing circuit performs an orthogonal transformation on a plurality of input subcarrier modulating data signals, to generate a time domain signal including said subcarriers.

37. A generator according to any of claims 30 to 36, in which said second signal processing circuit is an Inverse Fast Fourier Transformer.

38. A generator according to any of claims 30 to 37, in which said first format consists of one, two or three subcarriers and said second format consists of four or more subcarriers.

39. A generator according to any of claims 30 to 38, in which said second signal processing circuit is arranged to insert guard intervals of predetermined values at periodic intervals within said frequency multiplexed signal.

40. A multiplexed signal transmitter comprising a generator according to any of claims 30 to 39.

41. A satellite earth station comprising a transmitter according to claim 40.

42. A method of generating a frequency multiplexed signal, comprising the steps of selecting either a first signal format comprising a relatively small number of frequency multiplexed subcarriers or a second format comprising a larger number of subcarriers than the first; and either;

filtering one or more subcarrier input data signals using filters arranged to apply a relatively high degree of attenuation to the sidelobes of said subcarriers to produce said first format; or

generating a plurality of subcarriers in such a manner as to pass at least part of the first sidelobe of each said subcarrier to produce said second format.

43. A method of generating a frequency multiplexed signal comprising:

selecting the number of subcarriers in said signal; and, in dependence on said selection, either

applying pulse shaping filtering to a small number of input subcarrier modulating data signals to generate a first multiplexed format signal comprising a relatively small number of subcarriers; or

applying an Inverse Fourier Transform to a relatively large number of input subcarrier modulating data signals, to generate a frequency multiplexed signal in a second format comprising relatively large number of said subcarriers.

44. A frequency multiplexed signal generator comprising:

one or more pulse shaping filters;

a Inverse Fourier Transformer; and

a selector operatively coupled to interconnect input

subcarrier modulating signals to either said one or more pulse shaping filters or said Inverse Fourier Transformer.

45. A frequency multiplexed signal receiver comprising a first signal processing circuit for receiving a frequency multiplexed signal in a first format consisting of a small number of subcarriers, and a second signal processing circuit for receiving a frequency multiplexed signal in a second format comprising a larger number of subcarriers.

46. A receiver according to claim 45 in which the first signal processing circuit comprises at least one pulse shaping filter and the second signal processing circuit comprises an Inverse Fourier Transformer.

47. An OFDM transmitter comprising an OFDM generator for generating an ensemble of orthogonal, information-carrying frequency subcarriers, and a transmit filter for passing the subcarriers and at least a portion of the first sidelobes of the highest and lowest frequency subcarriers, and attenuating the second and subsequent sidelobes of said highest and lowest frequency subcarriers.

48. A transmitter according to claim 47, in which the filter has regular nulls which lie within said sidelobes, away from the nulls between said sidelobes.

49. A transmitter according to claim 47 or claim 48 comprising a control circuit for controlling the number of said subcarriers, and for controlling the bandwidth of said filter to match the number of said subcarriers.

50. A transmitter according to any of claims 47 to 49 in which the transition frequency of the filter passes through said first outer sidelobes of said highest and lowest frequency subcarriers.

51. A method of receiving an OFDM signal comprising filtering said signal to pass all the OFDM subcarriers and at least a portion of the first outer sidelobes of the highest and lowest frequency information-carrying subcarriers, and to attenuate frequencies outside the frequency of the second outer sidelobes of the said highest and lowest frequency subcarriers.

52. A method of filtering an orthogonal frequency division multiplexed signal comprising a plurality of orthogonal, information-carrying subcarriers each having a (sin x/x) spectral form, consisting of filtering said plurality of subcarriers so as to pass all said subcarriers and at least a portion of the first sidelobe of the highest and lowest subcarriers, and to attenuate the second and further sidelobes of said highest and lowest frequency subcarriers.

53. A method according to claim 51 or claim 52 in which the filtering transition frequency passes through the first outer sidelobes of the said highest and lowest frequency subcarriers.

54. A method according to any of claims 51 to 53 in which the filtering applies nulls within each of the second and further sidelobes, away from the nulls therebetween.

55. A receiver for receiving an OFDM signal comprising a filter with a pass band arranged to pass the subcarriers of said OFDM signal and at least a portion of the first outer sidelobes of the highest and lowest subcarriers present therein, and to attenuate frequencies corresponding to the spectral positions where the second and further outer sidelobes of said highest and lowest frequency subcarriers would be.

56. A receiver according to claim 55 further comprising

a control circuit for setting the bandwidth of said filter between at least first and second different values corresponding to at least first and second respective different numbers of subcarriers.

57. A receiver according to claim 55 or claim 56 which the transition frequency of the filter passes through said first outer sidelobes of said highest and lowest frequency subcarriers.

58. A receiver according to any of claims 55 to 57 in which the filter has regular nulls which lie within said sidelobes, away from the nulls between said sidelobes.

59. An OFDM signal comprising a plurality of orthogonal information-bearing subcarriers, the first outer sidelobes of the highest and lowest frequency said subcarriers being partially attenuated by filtering.

60. A method of processing an orthogonal frequency multiplexed signal modulated in symbol periods comprising:

a first step of reducing the magnitude of the signal over a symbol period so as to maintain orthogonality, and

where necessary, a second step of reducing the magnitude of particular temporal portions of the signal relative to others so as to reduce the peak-to-mean ratio of the multiplexed signal.

61. A method according to claim 60 in which said first step comprises the steps of:

testing the signal magnitude against a first predetermined threshold; and, in the event that any temporal portion of a symbol period exceeds said first threshold, reducing all temporal portions of the symbol period by the same factor.

62. A method according to claim 61, wherein said factor

is constrained not to exceed a second predetermined threshold and, in the event that said second predetermined threshold is not exceeded, said factor is such as to reduce the magnitudes of all temporal portions beneath said first predetermined threshold.

63. A method according to claim 62, in which said second step comprises the steps of comparing temporal portions of a symbol period, subsequent to processing by said first step, with a third predetermined threshold and, in the event that any of said temporal portions exceeds said third predetermined threshold, reducing said temporal portion magnitudes so as not to exceed said third predetermined threshold whilst leaving other temporal portion magnitudes, which do not exceed said third predetermined threshold, unmodified.

64. A method according to claim 63 in which said third predetermined threshold is higher than said first predetermined threshold.

65. An OFDM transmitter comprising:

a symbol power attenuator circuit (132) operable to evenly attenuate all successive samples of an OFDM symbol of excessive magnitude or peak to average ratio; and

a sample attenuator circuit (136) operable to selectively attenuate relatively high magnitude samples within the symbol period.

66. A receiver for a frequency multiplexed signal comprising a plurality of frequency subcarriers carrying information in symbol periods and having intervals of predetermined amplitude between said symbol periods, the receiver comprising a signal timing circuit arranged to generate a timing signal permitting the recovery of the information, said signal timing circuit being responsive to said intervals, said recovery being carried out on said multiplexed signal independently of the recovery of said

subcarriers.

67. A receiver according to claim 66 in which the signal timing circuit comprises an averaging circuit arranged to generate a signal responsive to the long term average value of the received signal at a point in time within the symbol period and previous signal values at corresponding points in time within previous symbol periods.

68. A receiver according to claim 67 in which the averaging circuit comprises a leaky integrator.

69. A receiver according to claim 67 or claim 68 further comprising a high pass circuit receiving the output of said averaging circuit and generating an output signal responsive to transitions in the output of said averaging circuit.

70. A receiver according to claim 69 in which the high pass circuit comprises a differencer.

71. A method of acquiring the timing within a frequency multiplexed signal which comprises a plurality of subcarriers each modulated synchronously with information in symbol periods separated by intervals of a predetermined magnitude, the method comprising the step of detecting said intervals prior to separation or demultiplexing said signal.

72. A method according to claim 71 comprising the step of performing long term averaging of each signal value at a point in a symbol period and the corresponding signal values at corresponding points in previous symbol periods.

73. A method according to claim 72 further comprising the step of differencing the averaged signal to detect transitions therein.

74. A frequency acquisition circuit for acquiring the

frequency of a signal modulated in a succession of symbol periods, and including first and second symbol periods, comprising:

a sampling circuit sampling over a fraction of each said symbol period;

a first frequency phasor circuit arranged to generate, responsive to said samples, an output signal indicative of the phase advance due to frequency offset between said first and second symbol periods over a first interval which is not an integral number of said symbol periods; and

a second frequency phasor circuit arranged to generate, responsive to said samples, an output signal indicative of the phase advance due to frequency offset over a second interval which is not equal to said first interval.

75. A circuit according to claim 74, in which said first and second intervals differ by no more than one symbol period.

76. A circuit according to claim 74 or claim 75 wherein said first and second intervals differ by no more than said fraction of a symbol period.

77. A circuit according to any of claims 74 to 76 wherein said fraction is approximately half of a symbol period.

78. A circuit according to any of claims 74 to 77 comprising a third frequency phasor circuit responsive to said samples to generate an output signal indicative of the phase advance over a third interval.

79. A circuit according to claim 78, wherein said second interval comprises an integral number of symbol periods and said first and third intervals comprise, respectively, a fraction of a symbol period more and a fraction of a symbol period less than said second.

80. A circuit according to any of claims 74 to 79 wherein each said frequency phasor circuit comprises a delay-multiply-average circuit.

81. A circuit according to any of claims 74 to 80 wherein the first and second symbol periods each include reference symbol data representing reference symbols of predetermined phase values, and the sampling circuit is timed to sample only said reference symbol data symbol periods.

82. A method of frequency acquisition for a signal modulated in symbol periods; comprising the steps of:

sampling symbol periods over fractions of their lengths, so as to pass frequencies higher than the reciprocal of the symbol period;

estimating the phase advance due to frequency offset over a first number of said samples and the phase advance due to frequency offset over a second number of said samples, said first and said second numbers corresponding to time periods which differ by an amount which is not an integer number of said symbol periods; and

forming a measure of the difference between the first and second phase advances to provide a frequency error estimate.

83. A method according to claim 82, wherein some of said symbol periods contain signals representing reference symbols recurring at regular intervals, and wherein said frequency error estimate is unambiguous over a frequency range greater than the reciprocal of the interval between reference symbols.

84. A method of decoding a convolutionally encoded and interleaved signal comprising the steps of:

sampling the signal;

reading each signal sample into a deinterleaver circuit in a first order;

reading each sample into a control circuit arranged to generate one or more control signals responsive to the level

of each sample;

reading the samples out of the deinterleaver in a second order;

quantizing the samples; and

decoding the quantized samples;

characterised by reading said samples into said control circuit in parallel with the reading thereof into said deinterleaver circuit, and by the step of aligning the range of the quantizer with that of the samples prior to reading the samples out of the deinterleaver circuit.

85. A decoder circuit for an interleaved and convolutionally encoded signal comprising a deinterleaver arranged to receive successive samples of the received signal; a quantizer arranged to receive samples read out from the deinterleaver circuit; and a decoder arranged to decode the quantized samples; characterised by a range control circuit operably connected to receive the samples in parallel with the deinterleaver circuit and to derive control signals for aligning the range of the quantizer and that of the samples read into the deinterleaver circuit, prior to read out of the samples from the deinterleaver circuit.

86. A satellite broadcasting system comprising a ground based broadcasting system transmitting an orthogonal frequency multiplexed signal and a repeater satellite in non geostationary orbit.

87. A system according to claim 86 in which each repeater satellite is arranged to generate a plurality of spot beams.

88. A system according to claim 86 or claim 87 comprising handover control means for transferring a receiver between two said beams or two said satellites.

89. A system according to any of claims 86 to 88 in

which the rate of transmission of data on said frequency multiplexed signal is increased prior to said handover.

90. A system according to claim 89 in which the number of subcarriers in said multiplexed signal is increased to increase the rate of transmission.

91. A ground station for a system according to any of claims 86 to 90.

92. A satellite for a system according to any of claims 86 to 90.

93. A receiver for a system according to any claims 86 to 90.

94. A receiver according to claim 93 comprising first and second acquisition circuits for acquiring signals from different said satellites.